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Usability Evaluation Report

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Executive Summary

A usability evaluation of SLEP (Service Life Extension Plan) VELCAC (Virtual Environment Landing Craft Air Cushion) was undertaken at IFE II in San Antonio, TX in mid February of 2003. This evaluation focused on a SLEP VELCAC system that is currently under development, but had a functional Craftmaster/Operator station and a partially functional Engineer station; the Navigator's station was not interactive at the time of evaluation. The SLEP VELCAC system is designed to provide differences training for those certified LCAC (Landing Craft Air Cushion) crewmembers that are transitioning from the traditional LCAC to the SLEP LCAC. The system is also designed to allow mission rehearsal or practice flights to work on crew coordination, cockpit familiarization, rehearsal of select emergency procedures, and practice with craft features unique to the SLEP upgrade.

The usability assessment consisted of heuristic evaluations conducted by two usability engineers and user testing of SLEP VELCAC's Craftmaster/Operator and Engineer stations to the extent afforded by the system's maturity. The heuristic evaluations employed traditional usability heuristics (Nielsen, 1993) and those developed specifically for virtual environments (Stanney, Reeves, Mollaghesmi, Breaux, & Graeber, in press) to find positive aspects of the system's design that uphold these guidelines, as well as areas that do not fully adhere to accepted design standards. One SLEP LCAC Craftmaster/Operator and one SLEP LCAC Engineer completed user testing sessions for their respective cockpit crew positions. User testing sessions focused on usability issues identified by the heuristic evaluations and interaction with the implemented features of SLEP VELCAC's Craftmaster/Operator and Engineer crew member positions. These sessions took the form of modified facilitated free play (Stanney & Reeves, 1995), where the participant was guided by the usability engineer to perform certain tasks while also given free reign to explore the system's capabilities and features. Example tasks participants were asked to complete include piloting the craft between two waypoints by the Craftmaster/ Operator, as well as recognizing and responding to the loss of APU and completion of a fuel transfer in response to a craft malfunction by the Engineer. The findings from both the heuristic evaluations and user testing were used to establish usability testing dependent measures and their associated acceptability criteria for future usability testing of SLEP VELCAC when more mature iterations of the system are developed. The aforementioned dependent measures and associated criteria levels were developed with input from the usability engineers, end-users, system developers, and sponsoring agency (ONR). These measures are presented in the form of a usability specification matrix (see Table 5).

The findings from the heuristic and user testing evaluations revealed a variety of positive aspects and user responses. Most notably, users stated that they could foresee the utility of SLEP VELCAC to support differences training when transitioning from the traditional to the SLEP LCAC. In addition, the Craftmaster/Operator noted that the virtual craft's dynamics and handling were replicated in a manner consistent with the actual craft. Results from the heuristic evaluations indicated SLEP VELCAC does a good job of replicating the crewstations and has the beginnings of a well designed training system. These analyses and the associated user testing revealed a number of usability concerns of varying priority levels that, if successfully resolved, have the potential to substantially improve the usability of the SLEP VELCAC. Table 1 presents high priority usability concerns and associated potential solutions. A more inclusive table of usability concerns is presented in Table 4.

Table 1. High priority usability concerns for SLEP VELCAC (February, 2003).

Usability Problem	User Impact	Recommended Solution	Resolution Priority
Unnatural to zoom via repeatedly depressing keys; can cause user disorientation/ frustration	H	<ul style="list-style-type: none"> Add quick zoom feature, possibly by adding default values matching how much user would zoom in to be able to view a screen (e.g., a user may not need a small incremental change, rather a 2X zoom) 	H
Changing point of view via repeatedly depressing keys is unnatural; can cause user disorientation/ frustration	H	<ul style="list-style-type: none"> Add a mouse function that allows the mouse to act as the user's eyes (for example, if the user scrolls to the left, the point of view moves to the left) 	H
Unnatural flow of information gathering/ integration resulting from having to zoom in on main or auxiliary display, which excludes supplemental information provided on other screen	H	<ul style="list-style-type: none"> Change the default view to increase clarity of the three screens necessary for Engineer's task performance. To accomplish this, consider removing non-task relevant graphics on the default view screen, changing font sizes, and increasing contrast of each screen 	H
Users' memory taxed with having to learn/remember keyboard commands	H	<ul style="list-style-type: none"> Use mouse or touch screen functionality to replace keyboard function (or use the keyboard as a redundant backup) 	M-H
Users' memory load is taxed by necessity to zoom in on the main or auxiliary display to read information, which excludes ability to see the other display	H	<ul style="list-style-type: none"> Change the default view to increase clarity of the three screens necessary for Engineer's task performance. To accomplish this, consider removing non-task relevant graphics on the default view screen, changing font sizes, and increasing contrast of each screen 	H
Labeling of displays is hard to read thus requiring user to recall functionality accessed via controls	H	<ul style="list-style-type: none"> Increase clarity of alphanumeric text via font size, sharpness, and contrast 	H
Inconsistent functioning of "ack" key to acknowledge alerts/ alarms	H	<ul style="list-style-type: none"> Change functionality to match operational functionality 	H
No indication of bow thruster status (stow v. operate) or direction (forward v. reverse) without viewing synthetic HUD, which does not exist in the craft	H	<ul style="list-style-type: none"> Create a bow thruster switch on the yoke that replicates the functionality of the bow thruster switch in the SLEP LCAC 	H
No ability to undo errors, thereby avoiding more critical errors	H	<ul style="list-style-type: none"> Add an undo option, in which a user can undo the last input (e.g. if a user accidentally turns off an engine, etc.) Add go back function so users can pick up situation at earlier point 	H
No on-line help available	H	<ul style="list-style-type: none"> Create a brief tutorial of how to interact with the VE Create a cut out keyboard cheat sheet to illustrate functionality Add a menu capability that allows users to have access to help 	H
Engineering station does not allow interaction with buttons on overhead console	H	<ul style="list-style-type: none"> Make high priority buttons, switches, etc. fully functional (see Stanney, Graeber, and Milham, 2002) 	H
Text on main and auxiliary displays is illegible when zoomed out and occasionally illegible when zoomed in	H	<ul style="list-style-type: none"> Ensure text is legible at both default and zoom in displays. Character height for maximum legibility/ readability is 20-22 arc min, for legibility minimum acceptable is 16 arc min; if individual characters do not have to be read, 10 arc min is minimum acceptable. Use sans serif font for small text and low resolution displays, otherwise use serif fonts [Source: DOT/FAA/CT-96/01] 	H
Users did not realize that the upper panels for each crewmember position were represented	H	<ul style="list-style-type: none"> Create an introductory screen illustrating the active parts of the display 	H
Repeated system lockups required rebooting of the system	H	<ul style="list-style-type: none"> Minimize system crashes 	H
When flying over land the engineer's controls became inactive	H	<ul style="list-style-type: none"> Implement fix 	H
Zoom in on engineer's main display (i.e. the 4 button) was not completely functional, it needed to be depressed numerous times (in some cases 15 times) before performing its function	H	<ul style="list-style-type: none"> Implement fix 	H
The inactive keys are causing confusion because they are in the incorrect non-default condition	H	<ul style="list-style-type: none"> Change default conditions to match real world default 	H

Key: H=High; M-H=Medium-High

¹ To account for both size of symbols/characters and viewing distance, visual angle is used as unit of measurement. Visual angles are specified in terms of minutes of arc or degree (1 degree = 60 minutes of arc).

Introduction

Full Product Description

The system under evaluation is the version of SLEP (Service Life Extension Plan) VELCAC (Virtual Environment Landing Craft Air Cushion) demonstrated at IFE II in San Antonio, TX mid February 2003. This system is currently undergoing an iterative development process in an effort to create a virtual environment training apparatus that supports both transition from the traditional LCAC (Landing Craft Air Cushion) to the SLEP LCAC and mission rehearsal or practice flights to work on crew coordination, cockpit familiarization, rehearsal of select emergency procedures, and practice with craft features unique to the SLEP upgrade. The components of SLEP VELCAC that were evaluated included the Craftmaster/Operator's station and the Engineer's station; the Navigator's station was not evaluated due to its limited development at the time of assessment. It should be noted that the Craftmaster/Operator position and Engineer position were not fully developed and thus bounded the depth of the usability evaluation. The Craftmaster/Operator station had functional craft controls and related gauges/displays for flight, however, the auxiliary display that allows viewing of navigation or engineering related information was not functional. The Engineer's station had more limited development, with the functionality of the UKB (Universal Keyboard), main display, and auxiliary display curtailed to support immediate actions associated with specific casualties (i.e. loss of APU) and monitoring of the plant during normal operations.

The intended user population for SLEP VELCAC comprises certified LCAC crewmembers that are transitioning from the traditional LCAC to the SLEP LCAC, as well as SLEP LCAC certified crewmembers. In essence, the user population consists of expert LCAC crewmembers that require a means for familiarization with the SLEP upgrades and ability to enhance crew fluidity that may have been altered by SLEP's technological advancements. For a thorough description of the user population's characteristics the reader is referred to Stanney, Graeber, and Milham (2002a; 2002b). The intended environment for use of SLEP VELCAC is both as a school house training system and a deployable system that could be utilized dockside or underway. A summary of SLEP LCAC crewmembers' views on intended use and after action review requirements is presented in Appendix A.

Test Objectives

The objective of this usability evaluation was the development of a usability specification matrix via heuristic evaluation and user testing. In achieving this main objective, sub-objectives were also attained, which included cataloging of positive design features and usability concerns associated with the SLEP VELCAC, as implemented at the time of evaluation. The usability specification matrix (USM) transforms general usability objectives (i.e., efficiency, intuitiveness, satisfaction) into specific measures that constitute usability requirements for a given system (Wixon & Wilson, 1997). The USM provides a means for evaluating SLEP VELCAC in later iterations of its design by establishing usability criteria, as well as acceptable levels for each criterion. The USM included herein utilizes four levels of acceptability: unacceptable, minimum, planned, and best case. The unacceptable level denotes a value for an attribute that signifies a serious usability violation that must be mitigated via redesign to avoid catastrophic (i.e., unrecoverable) usability impairment of the system. The minimum level establishes the minimum acceptable performance for the attribute and indicates that redesign should be undertaken to improve usability. The planned level is considered to be the target for usability success indicating that little to no redesign is required for assuring a usable system. Finally, the best case level is a level of performance that is optimal and could be theoretically achieved if a concerted effort, void of budget and time constraints, was devoted to system design, development, and usability engineering. This level is specified primarily as a target for future design iterations.

To compile the attributes for a usability specification matrix various approaches can be used, in this case heuristic evaluation implementing general usability heuristics (Nielsen, 1993) and virtual environment specific heuristics (Stanney, et al., under review), as well as user testing were used. These approaches reveal usability concerns associated with the system that can be folded into the usability specification matrix as attributes to be

tracked over the development of the system. Typically, only usability issues of high concern are included in the usability specification matrix because less serious usability violations can often be remedied through minimal redesign efforts. Specific usability questions asked by the development team are addressed in Appendix B.

Usability Attribute Table

Before constructing the usability specification matrix an initial step was the development of a usability attribute table based on the intended use of the system. The usability attribute table incorporates a variety of aspects that may affect the usability of the system and provides a focus for evaluative efforts and the generation of the usability specification matrix. In the case of SLEP VELCAC information pertaining to the users, tasks, system, and environment was captured in previous data collection efforts (see Stanney et al., 2002a; 2002b) and fused to create a compilation of key usability attributes for SLEP VELCAC. These attributes are presented in Appendix C and serve as a basis for guiding data collection efforts, generating the usability specification matrix, and specifying usability metrics. With the aforementioned usability attribute table in place, evaluative efforts of SLEP VELCAC could commence as described in the Method section.

Method

Experimental Design

The experimental design for this evaluation consisted of two phases. The first phase was the heuristic evaluation where general usability rules of thumb (Nielsen, 1993) and virtual environment specific usability guidelines (Stanney et al., in press) were used by usability engineers to systematically evaluate the SLEP VELCAC system. The second phase consisted of user testing designed to validate the heuristic evaluation findings and discover additional usability concerns via participants completing tasks and a free play session. Specific metrics were not employed for the user testing portion due to the immaturity of the system; instead the goal of the two phases was to establish which metrics should be utilized in subsequent usability evaluations, once the system is more mature.

Test Facility

The evaluation was conducted at SWRI (Southwest Research Institute) in San Antonio, TX. The SLEP VELCAC system was setup in a lab space that served the purpose of a development and demonstration facility for a variety of virtual environment systems. The setting for testing was akin to potential scenarios for SLEP VELCAC's use (i.e., classroom, deployed) due to the volume of people and other systems actively working in the room during data collection. This created a relatively noisy and dynamic environment where interruptions from individuals not involved with data collection occasionally occurred. The usability engineers conducting the user testing session do not feel these conditions withdrew from the validity of findings, but instead enhanced them because the setting was akin to actual training conditions at an ACU (Assault Craft Unit).

Participants

For the user testing portion of the evaluation two participants were involved. Both participants were certified SLEP LCAC crewmembers from ACU-5 at Camp Pendleton, CA; one a Craftmaster/Operator and the other an Engineer. These participants were selected because they are among the few individuals that have completed SLEP LCAC differences training and logged flight hours in a SLEP LCAC. User profile data (see Appendix D for questionnaire) were collected on these participants as well as a certified SLEP LCAC Navigator who gave input on the SLEP VELCAC system, their data are as follows. These crewmembers have logged between 200-330hr in a NDI equipped LCAC, 800-1400hr in a non-NDI equipped LCAC, and 3-40hr in a SLEP LCAC. All three crewmembers will undertake the role of SLEP LCAC instructor as more personnel complete the SLEP LCAC differences training. The survey respondents felt that there was a high level of automation in their jobs, they enjoy working with computers, and felt that the automation provided in SLEP LCAC has made their job easier. These individuals also noted that they find it challenging and rewarding to learn new computer applications, and that learning these applications pays off because it helps them complete a task faster or perform their job better.

These participants have been flying LCACs for 7-8 years and consider themselves experts in a traditional LCAC, but only novice or experienced in the SLEP LCAC. Their previous experience with U.S. Navy training systems resulted in the impression that these systems were somewhat effective in training critical job skills and somewhat easy to use. Finally, all three respondents were male between the ages of 26-40, possessed accurate depth perception, were not colorblind or physically disabled in a manner that would require special consideration, and one required the use of glasses to correct farsighted vision.

Procedure

Presented below is a brief discussion of the heuristics used to evaluate SLEP VELCAC followed by the tasks completed by participants during user testing. The heuristics employed were twofold, one was a more general set of guidelines, while the other was virtual environment specific. As a result, these provide a broad, high level means for assessing a product; an operational definition for each is provided in Table 2 below.

Table 2. General usability heuristics and their operational definitions.

Heuristic	Operational Definition
Simple and Natural Presentation	Task relevant information presented in a logical, natural, and streamlined fashion
Speak the User's Language	System interaction dialogue that is clear, concise, and consistent with user-defined domain; this could include mapping to the user's conceptual model
Minimize Memory Load	Recognition is better than recall; capitalize on affordances
Consistency	Interface should respond to user's actions in an expected and reliable manner
Feedback	Users should be aware of what system is doing and how it is interpreting their input
Clear Exits	Users should never feel trapped in a site, mode, or state of a system; undo capability is essential
Shortcuts	Provide expert users with means to quickly access desired system states
Errors, Error Handling, Error Prevention	Provide error correction and recovery before a permanent change occurs; tell users when and how a mistake was made, what can be done to correct it, and how to avoid the mistake in the future
Help	Provide on-line help within the application; provide plans or maps of the VE

The virtual environment specific usability heuristics employed in this evaluation were developed by Stanney, et al. (in press) to provide the usability engineering community a set of guidelines by which virtual environments and their unique usability challenges could be evaluated. These guidelines go beyond traditional usability considerations taking into consideration aspects such as the design of wayfinding and navigational techniques, object selection and manipulation, visual, auditory and haptic system outputs, presence, immersion, and system comfort, as well as minimizing sickness and deleterious aftereffects. The heuristics from Stanney et al.'s (in press) that are relevant to SLEP VELCAC are provided below in Table 3.

Table 3. Virtual environment specific usability heuristics and their operational definitions.

Heuristic	Operational Definition
Interaction	Interaction should be natural, efficient, and appropriate for target users, domains, and task goals
Wayfinding	Provide ability to maintain knowledge of one's location and orientation while moving throughout a designed space
Navigation	Intuitive navigational control should be provided in a streamlined fashion
Object selection and manipulation	Process of indicating virtual objects within an environment to reposition, reorient, or query them should not be awkward or disorienting
Visual	Consideration of effectiveness of stereoscopic support, spatial resolution, field-of-view-update rates, refresh rates, and user comfort and acceptance should be given
Engagement	Engagement in virtual environment should be fostered and sustained, thereby enhancing

	sense of presence
Presence	Enhance the subjective perception of experiencing oneself as being in a computer-generated environment rather than in one's actual physical location
Immersion	Enhance the perception of oneself being enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences
Comfort	Overall physical discomfort should be minimized, while user safety is maximized

Note: this table excludes the Stanney et al.'s (in press) heuristics on haptic and auditory output, as well as sickness and aftereffects because it is not felt they are a concern at this juncture.

The user testing portion of the usability evaluation consisted of the Engineer and Craftmaster/Operator performing scenario setup procedures, and general navigation and object manipulation in the VE; the Engineer was also asked to complete a specified casualty procedure. Due to the current state of SLEP VELCAC's development, scenario setup was limited to logging into the system. When a more dynamic scenario setup capability is developed the task of configuring and beginning a user session will be revisited more thoroughly.

The next area of focus for user testing completed by both Engineer and Craftmaster/Operator included general navigation through the VE; manipulating objects in the VE; examining the readability and utility of essential screens/displays/gauges, and UKB buttons and auxiliary displays. (Note only the Engineer had a functioning UKB and auxiliary display). These tasks are critical to the user's ability to interact with and within the VE, as well as obtain requisite information to support the intent of a user session.

Finally, the Engineer completed a casualty procedure that involved mitigating the loss of the APU (see Appendix E for an updated list of tasks that an Engineer performs to deal with loss of the APU). APU failure was chosen as a representative casualty for this iteration of SLEP VELCAC because it is a realistic malfunction that the Engineer would rehearse in both SLEP LCAC differences training and in an operational setting. However, only portions of the immediate actions associated with the casualty could be evaluated due to the maturity of SLEP VELCAC. As a result, user testing focused on those portions of the casualty mitigation procedure that were functional, as well as identifying additional key elements of the task needed to round out the complete suite of functionality and displays requisite for effectively undertaking appropriate immediate actions.

While performing the aforementioned tasks, users were provided with a "cheat sheet" of keyboard and mouse functions to assist in choosing the proper means for manipulating objects and moving within the environment. However, it should be noted that the "cheat sheet" could only be accessed via a paper based document and thus presented a barrier to its efficient use while completing tasks with SLEP VELCAC. Finally, user testing conducted on this iteration of SLEP VELCAC was focused more on a qualitative evaluation of the system to identify areas of concern via errors and user frustration rather than an objective cataloging of traditional usability metrics (i.e., time in error, number of errors, time to complete tasks, etc.).

Results

Problem-Solution Table

The problem solution table below (see Table 4) presents a summary of the usability concerns based on the heuristic evaluation and user testing findings for both the general and virtual environment heuristics (see Appendix F for complete heuristic evaluation findings). Along side each usability concern, the table provides potential impact on users, suggested remedies, and the importance of having the concern addressed via redesign. This table is based on the limited SLEP VELCAC functionality available today. After each IFE usability evaluation, a problem solution table will be generated that focuses on advancing functionality as the SLEP VELCAC system matures.

Table 4. Problem-solution table for SLEP VELCAC usability concerns.

Usability Concern	User Impact	Recommended Solution	Resolution Priority
Simple and Natural Presentation Heuristic			
Using the mouse to interact with the UKB is not natural	L	<ul style="list-style-type: none"> • Add touch screen capability so that users can interact directly with the UKB 	L
Using the mouse to interact with other switches, knobs, dials is not natural	L	<ul style="list-style-type: none"> • Allow users to directly touch interface via touchscreen 	L
Rotating point of view up with the "S" key and down with the "W" key is counter intuitive; can cause user disorientation/ frustration	M	<ul style="list-style-type: none"> • Switch the functionality of the keys: change the "S" key to shift point of view down and the "W" key to shift point of view up 	M-L
Unnatural to zoom via repeatedly depressing keys; can cause user disorientation/ frustration	H	<ul style="list-style-type: none"> • Add quick zoom feature, possibly by adding default values matching how much a user would zoom in to be able to view a screen (e.g., a user may not need a small incremental change, rather a 2X zoom) 	H
Changing point of view via repeatedly depressing keys is unnatural; can cause user disorientation/ frustration	H	<ul style="list-style-type: none"> • Add a mouse function that allows the mouse to act as the user's eyes (for example, if the user scrolls to the left, the point of view moves to the left) 	H
Unnatural flow of information gathering/integration resulting from having to zoom in on main or auxiliary display, which excludes supplemental provided on other screen	H	<ul style="list-style-type: none"> • Change the default view to increase clarity of the three screens necessary for Engineer's task performance. To accomplish this, consider removing non-task relevant graphics on the default view screen, changing font sizes, and increasing contrast of each screen 	H
Users did not realize that the upper panels for each crewmember position were represented	H	<ul style="list-style-type: none"> • Create an introductory screen illustrating the active parts of the display 	H
Users suggested horizon shot wasn't correct, too much water, not enough sky	L	<ul style="list-style-type: none"> • Change the water/sky ratio to reflect real world visual (40%/60%) 	L
Alarms on engineer's auxiliary page flash in the actual craft when they have not been acknowledged, but they do not in SLEP VELCAC	M	<ul style="list-style-type: none"> • Changing functionality to reflect real world functionality 	M-H
The inactive keys are causing confusion because they are in the incorrect non-default condition	H	<ul style="list-style-type: none"> • Change default conditions to match real world default 	H
Speak the User's Language Heuristic			
User's language is not utilized to its fullest extent possible in the "cheat sheet"	M	<ul style="list-style-type: none"> • Change terms to be more coherent (e.g. zoom in vs. move view left, right, forward, backward) 	M-L
Minimize Memory Load			
User's memory taxed with having to learn/ remember keyboard commands	H	<ul style="list-style-type: none"> • Use mouse or touch screen functionality to replace keyboard function (or use the keyboard as a redundant backup) 	M-H
User's memory load is taxed by necessity to zoom in on the main or auxiliary display to read information, which excludes ability to see the other display	H	<ul style="list-style-type: none"> • Change the default view to increase clarity of the three screens necessary for Engineer's task performance. To accomplish this, consider removing non-task relevant graphics on the default view screen, changing font sizes, and increasing contrast of each screen 	H
Labeling of displays is hard to read thus requiring user to recall functionality accessed via controls	H	<ul style="list-style-type: none"> • Increase clarity of alphanumeric text via font size, sharpness, and contrast 	H
Consistency Heuristic			
Inconsistent function for the "1" key; first press shows Navigator's main display, subsequent press shows last point of view	M	<ul style="list-style-type: none"> • Create consistent mapping of key presses 	M-H
Inconsistent functioning of the "ack" key to acknowledge alerts and alarms	H	<ul style="list-style-type: none"> • Change functionality to match operational functionality 	H
Feedback Heuristic			
Visuals do not give any sense of craft speed	M	<ul style="list-style-type: none"> • Add additional visual cues to increase optic flow 	M-L
No collision detection over land	M	<ul style="list-style-type: none"> • Add collision detection 	M-H (H if using for

			practicing beach landing)
System locks up without telling the user why it locked up	M	<ul style="list-style-type: none"> Add diagnostic error messages (e.g. what happened and what the user can do to go back or restart, if necessary) 	M-L
No indication of bow thruster status (stow v. operate) or direction (forward v. reverse) without viewing synthetic, HUD which does not exist in the craft	H	<ul style="list-style-type: none"> Create a bow thruster switch on the yoke that recreates the functionality of the bow thruster switch in the SLEP LCAC 	H
Clear Exits Heuristic			
No pause capability	M	<ul style="list-style-type: none"> Add a pause capability 	M-H
No ability to go back to a particular part of a scenario (can only restart)	M	<ul style="list-style-type: none"> Add a menu system, in which users can exit, pause, and go back to particular parts of the scenario 	M-H
Shortcuts Heuristic			
No ability to choose where along a route or task completion to start a scenario	M	<ul style="list-style-type: none"> Add a menu system, in which users can start at particular parts of the scenario 	M-H
Errors, Error Handling, Error Prevention Heuristic			
No ability to undo errors, thereby avoiding more critical errors	H	<ul style="list-style-type: none"> Add an undo option, in which a user can undo the last input (e.g. if a user accidentally turns off an engine, etc.) Add go back function so users can pick up situation at earlier point 	H
When system locks up there is no indication of why or when via error messages	H	<ul style="list-style-type: none"> Provide appropriate error message for system lock ups 	
Repeated system lockups required rebooting of the system	H	<ul style="list-style-type: none"> Minimize fatal system errors 	H
When transitioning from surfzone to land the Craftmaster/Operator's heading indicator malfunctioned		<ul style="list-style-type: none"> Implement fix 	H
When flying over land the engineer's controls became inactive	H	<ul style="list-style-type: none"> Implement fix 	H
Zoom in on engineer's main display (i.e. the 4 button) was not completely functional, it needed to be depressed numerous times (in some cases 15 times) before performing its function	H	<ul style="list-style-type: none"> Implement fix 	H
Help Heuristic			
No on-line help available	H	<ul style="list-style-type: none"> Add a brief tutorial on how to interact with the VE Add a cut out keyboard cheat sheet to illustrate functionality Add a menu capability that allows users to have access to help 	H
Interaction Heuristic			
Interaction with SLEP menu screens limited to UKB	L	<ul style="list-style-type: none"> No solution is required 	L
Engineering station does not allow interaction with buttons on overhead console	L*	<ul style="list-style-type: none"> Make high priority buttons, switches, etc. fully functional (see Stanney, Graeber, and Milham, 2002) 	M*
Navigation Heuristic			
Lack of collision detection allows user to zoom point of view outside of cockpit	M	<ul style="list-style-type: none"> Constrain movement of viewpoint to within the cockpit 	M-L
Visual Heuristic			
Text on main and auxiliary displays is illegible when zoomed out and occasionally illegible when zoomed in	H	<ul style="list-style-type: none"> Ensure text is legible at both default and zoom in displays. Character height for maximum legibility/readability is 20-22 arc min, for legibility minimum 	H

		acceptable is 16 arc min; if individual characters do not have to be read, 10 arc min is minimum acceptable. Use sans serif font for small text and low resolution displays, otherwise use serif fonts [Source: DOT/FAA/CT-96/01]	
When transitioning from surfzone to land a greenish brown bar fills a majority of screen	L	• Implement fix	L

*Engineer's overhead panels need to be active if the intended use of the system includes start up procedures and formation flying

Usability Specification Matrix

The usability specification matrix presented below in Table 5 contains traditional usability metrics that are applicable to a variety of systems, including virtual environments, and critical usability concerns unveiled in the heuristic evaluation and user testing. This table was drafted by the usability engineers conducting the SLEP VELCAC evaluation and discussed in a focus group that invited feedback from end users, system developers, and the sponsoring agency. The result of that discussion was the generation of values for the various levels of acceptance for each usability attribute listed in the matrix; in some cases values will be established at a later date when additional data on the system are provided by system developers. This matrix may continue to evolve with successive iterative evaluations of SLEP VELCAC via discussion among the aforementioned individuals involved in setting the baseline for critical usability attributes and their acceptability criteria.

Regardless of edits to the matrix, the attributes presented herein and their associated levels of acceptability will serve as the usability standards the system will be evaluated against as it matures.

Table 5. SLEP VELCAC Usability Specification Matrix.

Attribute	Measuring Instrument	Measuring Method	Unacceptable Level	Minimum Level	Planned Level	Best Case Level
Time in errors	<ul style="list-style-type: none"> VE Setup <ul style="list-style-type: none"> Stand alone Via BMEC User movement in VE <ul style="list-style-type: none"> Input errors (e.g. clicking on inaccessible parts of screen) Stroking incorrect keyboard commands Disorientation in VE After Action Review 	Average percentage	25%	10%	0-10%	0%
# of subsequent errors	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run After Action Review 	Average number	>1	1	1	0
Time to commence scenario	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC full setup BMEC partial setup 	Average time	TBD	TBD	10min	5min
Use of cheat sheet	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run After Action Review 	Average number in 30mins	>6	6	4	1
Frequency of use of help	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run 	Average number in 30mins	>4	4	2	0
Number of workarounds	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run <ul style="list-style-type: none"> (e.g. turning craft to change 	Average number	>2	2	1	0

	POV instead of manipulating POV via keyboard) <ul style="list-style-type: none"> Skipping steps due to system constraints (e.g. skipping steps in a procedure due to inactive controls/displays After Action Review 					
Positive vs. negative comments	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run After Action Review 	Average percentage	>10%	10%	5%	0%
Number of comments expressing frustration	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run After Action Review 	Average number	>2	2	1	0
Satisfaction	<ul style="list-style-type: none"> Setup <ul style="list-style-type: none"> Stand alone BMEC Scenario run After Action Review 	Average rating on 7pt Likert scale (7 is high satisfaction)	≤ 4	5-6	6	7
Proportion of users that find system useful	<ul style="list-style-type: none"> Perception based on complete session 	Average percentage	≤ 60%	70%	90%	100%
Intuitiveness	<ul style="list-style-type: none"> Memorability of keyboard commands Memorability of user input commands 	Average percentage	≤ 60%	70%	90%	100%
Utility	<ul style="list-style-type: none"> Degree to which system supports user's task (note: exact tasks will be determined as system matures) Time it takes to navigate between screens/displays used to complete a task Switching of view to complete a task 	<ul style="list-style-type: none"> Number of inactive controls/displays needed to complete a task (provided task can still be completed) Average number Average Number 	2 TBD 2	1 TBD 1	0 TBD 0	0 0 0
Consistency of VE	<ul style="list-style-type: none"> Displays/commands reflect real world terminology 	Average percentage	<90%	90%	95%	100%
Readability	<ul style="list-style-type: none"> Percentage of text critical to task completion that is readable 	Average percentage	100%	100%	100%	100%

TBD = To be determined

- VE Setup: steps users must take from when they sit down at VE to when turn computer off at session end
- Stand alone: individual or LCAC crew use
- Via BMEC: using scenario building tool
- Scenario run: user interaction with VE during scenario run
- User movement in VE : interaction with mouse/keyboard and VE
- After Action Review: user interaction with AAR system

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Appendix A

User Interview on SLEP VELCAC Intended Use and After Action Review (AAR)

While conducting participant interviews the topics of SLEP VELCAC's intended use and After Action Review (AAR) capabilities were discussed. Presented below is a summation of the feedback on the aforementioned topics from the Navigator's and Craftmaster/Operator's perspectives. With respect to SLEP VELCAC's intended use the Navigator felt that the system would be ideal for aiding differences training when transitioning from the traditional to the SLEP LCAC. In particular, demonstrating cockpit layout differences, navigating the menu structures associated with the Navigator's equipment, learning procedures associated with the UKB (Universal Keyboard) and auxiliary display. To accomplish this, the Navigator felt SLEP VELCAC would need a fully functional UKB, auxiliary display, main display and trackball; out-the-window visuals and other cockpit features are of lesser importance or not needed. The Craftmaster/Operator had a more limited input to the intended use of SLEP VELCAC, which is not surprising given the minimal differences between traditional and SLEP craft for that crewmember. The Craftmaster/Operator interviewed felt that SLEP VELCAC would be advantageous for gaining an understanding of the changes to the Engineer's position and capabilities in the SLEP LCAC (i.e. cross seat training). Other uses for SLEP VELCAC as a training system were not suggested because there are no differences in flying a SLEP vs. traditional LCAC or the Craftmaster/Operator's immediate actions in response to casualties. However, it was felt that SLEP VELCAC may prove beneficial for enhancing crew coordination when practicing "canned" scenarios in generic environments.

The second area of focus during the interviews was AAR, specifically, discussing what types of data need to be captured to create an effective AAR training tool. The end users interviewed were unified in their response to this topic conveying the universal benefit of their input. It was felt that differences training would benefit immensely from AAR capabilities, in particular, depicting the user's path when navigating the SLEP menu structures in contrast to an optimal path (e.g. fewest steps) to aid learning of menu structures and efficient use of SLEP upgrade functionality. This capability would be applicable to a variety of scenarios from initializing the craft pre-flight, to taking immediate actions as a result of a casualty, to understanding how an individual arrived at their final outcome for a task (e.g. information used and sequence in which the information was accessed). Interestingly, this group of interviewees felt that some of the AAR dependent measures gathered via previous interviews may be of little use. In particular, the Navigator felt that measures such as time to react to a contact or casualty and number of waypoints hit were not effective data to present in AAR due to the dynamic nature of the LCAC's operational environment. With respect to using SLEP VELCAC for practicing scenarios in generic environments, it was expressed that data reflecting how well mission related criteria were met (e.g. h-hour, staying within a swept channel, adherence to SEAOPS, and meeting mission objectives) would be most useful.

Appendix B

Response to Richard Schaffer's Usability Evaluation questions

Here are some SIM issues you may wish to evaluate as part of the TEE effort at IFE2. These would be helpful to the SIM group.

1) Windows are a problem in the real LCAC. We can have no glass (perfect view), standard glass reducing contrast), or cracked glass with condensation. We have examples of the first 2.

- If mission rehearsal, then cracked glass might be useful to simulate real world conditions
- Fog would be better
- If SLEP basic buttonology is the main training objective, then standard glass may be the best option

2) Acceptability of current 4 Engineer main screens and associated functionality.

- Aux screens difficult to read
- Zoom-in version of the main screens are still difficult to read
- Functionality isn't complete
- Screen by screen review in upcoming report

3) Value of "zoom-in" keys to enhance the readability of main screens.

- Arrows: for engineer purpose good, need to improve speed of access
- Quick zoom functionality is necessary

4) Review of rough scaling of TF-40B to ETF-40B engine parameters.

- EGTs would be 850-900 at 95% N2

5) Review of Fuel Manifold failure procedures and simulator responses.

- Update available (Chris also has partial data on this)

6) Utility of low cost HMDs (2 available).

- No for Navigator and Engineer, yes for Craftmaster

7) Utility of AARS playback of displays.

- Get more focused data than a playback (see ACU5 report)

Appendix C

Usability Attribute Table

Table C. Usability attribute table.

User Characteristics	User Environments	User Tasks	Important Usability Attributes
<p><i>Craftmaster</i></p> <ul style="list-style-type: none"> • 81.3% like working with computers • 93.3% at least sometimes enjoy learning new computer applications • 100% are interested in computers for their job or in general • 31.3% report moderately low computer experience • 81.3% report that they are expert Craftmasters • 100% have at least HS education • 37.5% report that past training systems have been completely effective • 43.8% report that past training systems were easy to use 	<p><i>VELCAC</i></p> <ul style="list-style-type: none"> • Limited to no setup and runtime support for the VELCAC configuration and scenario generation • There may be interruptions while using the VELCAC • The Craftmaster may not have the whole crew available for training • If the actual LCAC run is close in time to the VELCAC run, need to eliminate any after effects (e.g. simulator sickness; this is being assessed by other members of the VELCAC team) • In the LCAC, the cockpit crew turns down the cockpit lighting to develop their night vision for night runs. If night conditions are simulated, need to consider if the crew will be given time and capability to develop night vision 	<p><i>Preflight</i></p> <ul style="list-style-type: none"> • Involved in planning to a limited degree: provides input to brief preparation <p><i>Scenario run</i></p> <ul style="list-style-type: none"> • In charge, most responsible for mission accomplishment • Major task is to fly the LCAC • Does this by maintaining course, maintaining speed, making turns, listening to radios, lining up visually with beach, looking for and maneuvering around obstacles • Accomplished by looking at displays and window for inputs • Controls the craft by physically manipulating controls • To accomplish this, he wants to know how variables impact LCAC performance (e.g. beach variables, LCAC/performance variables) <p><i>Debrief</i></p> <ul style="list-style-type: none"> • Wants to know if the craft hits the beach at the designated time • Graded on craft control • Graded on how they react to navigation problems, extreme situations and casualties • Graded on how well they follow the rules of the road, avoiding contacts and maintaining timing 	<ul style="list-style-type: none"> • High ease of use and intuitiveness: system needs to be able to be easily configurable for hardware (i.e. HMD) and scenario generation, due to the lack of technical support and low computer experience of crewmembers • System efficiency: need for low number of steps for system configuration: possibly have the system remember from logon (e.g. have a ship profile from previous runs) • System configuration and scenario generation should not take a lot of time • System effectiveness: for the Craftmaster, system must provide the appropriate level of fidelity to support major tasks. For surf zone transitions and beach landings, it is critical that contacts (e.g. boats, ships, buoys) and beach variables are very similar to the real world. To physically control the craft, it is important that the movements and actions of the ship match that of the LCAC. The dial-a-LCAC capability requires that the VE system replicates the visuals and “feeling” (e.g. the LCAC should respond realistically) of the various LCAC performance variables. Please see section V and VI for a full set of recommendations for fidelity of physical systems and environments • Satisfaction: because of the Craftmaster’s leadership role, may be more important that he feels that the

Table C. Usability attribute table.

User Characteristics	User Environments	User Tasks	Important Usability Attributes
		<ul style="list-style-type: none"> • Team performance • How long it took for the LCAC to go off cushion • How long it took the LCAC to get over the hump • Craft performance (i.e. fuel burn) • Wants to know the track of friendly craft • Wants to know hot areas • Wants to have different viewpoints: out of the window for waypoints, surf transitions and beach landings, in addition to god's eye • Wants to have contact information (e.g. track) • Wants to know separation between craft 	<ul style="list-style-type: none"> • VELCAC is a useful product • System efficiency: Due to possible interruptions in the scenario generation and the scenario run, the VE should allow users to save and reopen scenario building files and to provide pausing and restarting functions during the scenario run • System effectiveness: if the whole crew is unavailable for training, synthetic agents should be able to simulate crewmembers • System efficiency: if simulator sickness from HMD-based VELCAC effects LCAC performance, then the system should provide options/ alternatives (e.g. monitors only vs. HMD) to support mission rehearsal just prior to mission conduct

Table C: Usability attribute table. (cont..)

User Characteristics	User Environments	User Tasks	Important Usability Attributes
Navigator <ul style="list-style-type: none"> 71.4% like working with computers 92.8% at least sometimes enjoy learning new computer applications 92.8% are interested in computers for their job or in general 28.5% report low or moderately low computer experience 71.4% report that they are expert Navigators 100% have at least HS education* 	VELCAC <ul style="list-style-type: none"> May not have a lot of time between getting OPTASK AMPHIB and LCAC run Mission planning may take the Navigator up to 2 hours, may have limited time to set up mission rehearsal scenarios Limited to no setup and runtime support for VELCAC configuration and scenario generation The Navigator may not have the whole crew available for training If the actual LCAC run is close in time to the VELCAC run, need to eliminate any after effects (e.g. simulator sickness; this is being assessed by other members of the VELCAC team) May be subject to a number of interruptions during planning/scenario setup [room is not dedicated] LCAC <ul style="list-style-type: none"> In the LCAC, the cockpit crew turns down the cockpit lighting to develop their night vision for night runs. If night conditions are simulated, need to consider if the crew 	<p><i>Preflight planning</i></p> <ul style="list-style-type: none"> Heavily involved in planning, takes OPTASK information and will a) plot track data and b) build mission brief Sets up briefing so may want to show outputs to others (e.g. deconfliction) Will check sources (ship log, internet) for updates on environmental information <p><i>Scenario run</i></p> <ul style="list-style-type: none"> Major task is to assess and maintain correct course, track and speed to ensure they hit the beach on time; providing track and speed information to the Craftmaster; looking for obstacles on the radar and out the window; communicating with other craft To accomplish these tasks, the Navigator is constantly looking at radar for distances to contacts, other craft; looking out the window for contacts and for map correlation (e.g. buoys); looking at maps, charts, GPS to assess track; calculating speeds <p><i>LCAC</i></p> <ul style="list-style-type: none"> In the LCAC, the cockpit crew turns down the cockpit lighting to develop their night vision for night runs. If night conditions are simulated, need to consider if the crew 	<ul style="list-style-type: none"> High ease of use and intuitive: the Navigator is likely to be the individual who will input information, as he plays a significant role in mission planning. Due to low computer experience, the configuration and scenario generation should be easy to use and intuitive System efficiency: Debrief summary information and animation should be able to be exported to Microsoft PowerPoint. System efficiency: the Navigator may not have time to generate a complete mission, so the system must support different levels of interaction (develop own scenario vs. have some variables random or chosen) System efficiency: may be under time constraints, so system should have shortcuts to scenario design System efficiency: scenario development time should be short Flexible: important to support investigating how different variables such as wind will impact track and speed) System efficiency: VELCAC should support Navigator's mission rehearsal needs to assess how variations of variables impact track and craft performance (e.g. how different speeds impact hitting checkpoints; how different gradients impact the speeds needed to land on beach). To support this, the

Table C. Usability attribute table. (cont.)

User Characteristics	User Environments	User Tasks	Important Usability Attributes
	<ul style="list-style-type: none"> will be given time and capability to develop night vision In the LCAC, the windows can be foggy and cloudy In the LCAC, the background noise is very loud, need to consider if the background should be simulated 	<p>fidelity of outside comms are very important</p> <ul style="list-style-type: none"> During the run, the Navigator is providing constant backup to Craftmaster Debrief <ul style="list-style-type: none"> Wants to know if the crew hit checkpoints on time Wants to know how variables (e.g. sea, winds) affected the timing and track of LCAC Wants to know if they hit the H-hour or if not how much they were off Wants to know the track of friendly craft Wants to know hot areas Want to have different viewpoints: out of the window for waypoints, surf transitions and beach landings, in addition to god's eye Wants to have contact information (e.g. track) Wants to know separation between craft 	<p>system should provide an option to allow crewmembers to stop and reset variables during scenario play, while allowing them to restart where they left off or at other points in the mission</p> <p>System effectiveness: system must support Navigator tasks, those cues that impact performance must have appropriate fidelity. See sections V and VI for recommendations for physical systems and environmental that support Navigator tasks</p> <p>Flexible output: crewmembers should be allowed to select the kinds of information they are interested in.</p> <p>Navigators should be able to select in addition to or separately from other crewmember's feedback. Navigators may be interested in feedback on how environmental (e.g. wind) impacted the craft's track, contact information (e.g. how close the formation was to various contacts), and other needs detailed in the previous column and in the debrief section of this document</p> <p>System efficiency: Due to possible interruptions in the scenario generation and the scenario run, the VE should allow users to save and reopen scenario building files and to provide pausing and restarting functions during the scenario run</p> <p>System effectiveness: if the whole crew is unavailable for training, synthetic agents should be able to simulate</p>

Table C. Usability attribute table. (cont.)

User Characteristics	User Environments	User Tasks	Important Usability Attributes
			<ul style="list-style-type: none">crewmembersSystem efficiency: if simulator sickness from HMD-based VELCAC effects LCAC performance, then the system should provide options/alternatives (e.g. monitors only vs. HMD) to support mission rehearsal just prior to mission conduct

Table C. Usability attribute table. (cont.)

User Characteristics	User Environments	User Tasks	Important Usability Attributes
<p>Engineer</p> <ul style="list-style-type: none"> • 52.9% like working with computers • 100% at least sometimes enjoy learning new computer applications • 94.1% are interested in computers for their job or in general • 58.9% report low or moderately low computer experience • 52.9% report that they are expert Engineers • 94.1% have at least HS education • 26.7% report that past training systems have been completely effective • 20% report that past training systems were easy to use 	<p>VELCAC</p> <ul style="list-style-type: none"> • Limited to no setup and runtime support for the VELCAC configuration and scenario generation • There may be interruptions while using the VELCAC • If the actual LCAC run is close in time to the VELCAC run, need to eliminate any after effects (e.g. simulator sickness; this is being assessed by other members of the VELCAC team) • In the LCAC, the cockpit crew turns down the cockpit lighting to develop their night vision for night runs. If night conditions are simulated, need to consider if the crew will be given time and capability to develop night vision • In the LCAC, the windows can be foggy and cloudy • In LCAC, background noise is very loud, need to consider if background should be simulated <p>LCAC</p> <ul style="list-style-type: none"> • How long it took for the LCAC to go off cushion • How long it took the LCAC to get over the hump • Craft performance (i.e. fuel burn) • May be interested in the speed and power settings' impact on beach landing 	<p><i>Preflight planning</i></p> <ul style="list-style-type: none"> • Involvement is limited, but are concerned with cargo load weight and distribution, as well as fuel load <p><i>Scenario run</i></p> <ul style="list-style-type: none"> • Wants to know how sea state impacts engine performance • Second set of eyes, so visuals are important (know what to look for) • Backup role to the Craftmaster by looking out the window • Tasks are to transfer fuel, monitoring the Engineering plant, looking for contacts, assessing beach gradient, and assessing the speed of the Craftmaster • In the LCAC, the Engineer primarily deals with casualties <p><i>Debrief</i></p> <ul style="list-style-type: none"> • How long it took for the LCAC to go off cushion • How long it took the LCAC to get over the hump • Craft performance (i.e. fuel burn) • May be interested in the speed and power settings' impact on beach landing 	<ul style="list-style-type: none"> • System effectiveness: The system should provide opportunities to practice backup tasks • System effectiveness: the VELCAC should support the Engineer's non-casualty tasks. The AMS pages should have either functional fidelity; if the Navigator transfers fuel, the craft performance should be adjusted accordingly

Appendix D

User Profile Questionnaire

We would be most appreciative if you would complete this questionnaire so we may better understand you as a user. Thank you for your time and your participation is greatly appreciated.

1. Your job title is (e.g. Craftmaster, Navigator, Engineer): _____
2. How many hours have you flown on NDI equipped LCACs? _____
3. How many hours have you flown on non-NDI equipped LCACs? _____
4. How many hours have you flown on the SLEP LCAC? _____
5. Are you an instructor on the SLEP LCAC? _____

If so, briefly describe the course content (e.g. highlighting differences between traditional and SLEP LCAC, etc.) _____ not designed yet

6. Describe the current level of automation of your job while in the SLEP LCAC:

- None (There is no automation of my job in the SLEP LCAC)
- Low (Use SLEP LCAC controls and displays 1-30% of the time in-flight)
- Medium (Use SLEP LCAC controls and displays 31-70% of the time in-flight)
- High (Use SLEP LCAC controls and displays 71-100% of the time in-flight)

7. In general how do you feel about working with computers?

- I don't like working with computers.
- I have no strong like or dislike for working with computers.
- I like working with computers.
- Other (please explain) _____

8. How have computers affected your job?

- Automation in the SLEP LCAC has made my job easier.
 Automation in the SLEP LCAC has not affected my job in any particular way.
 Automation in the SLEP LCAC has made my job more difficult.
 Other (please explain) _____

9. Is the amount of time it takes to learn new computer applications usually worth it?

- Yes, it pays off because computer systems usually help me do my job better or faster.
 Sometimes, it pays off, and sometimes it doesn't.
 No, computer systems are usually not useful enough to justify the training time.
 Other (please explain) _____

10. Do you enjoy learning how to use new computer applications?

- Yes, it's usually challenging and interesting.
 Sometimes, depending on the application.
 No, it's usually tedious and frustrating.
 Other (please explain) _____

11. In general, are you interested in computers?

- I am not interested in computers and would avoid using them if I could.
 I am interested in computers but only as a means to help me do my job better and faster.
 I am interested in computers in general, and I enjoy using them.
 Other (please explain) _____

12. How many years since you became "certified" in your current LCAC crewmember position: _____

13. What is your highest academic degree?

- No degrees
- High school degree
- Trade or vocational school degree (beyond the high school level)
- College degree (for example, B.A., B.S., Associate)
- Graduate degree (for example, M.A., M.S., Ph.D., Ed.D., M.D., R.N.)
- Other (please explain) _____

14. How would you describe your skill level as a "certified" LCAC crewmember in your current job title?

- Novice
- Experienced
- Expert
- Other (please explain) _____

15. How would you describe your skill level as a "certified" SLEP LCAC crewmember in your current job title?

- Novice
- Experienced
- Expert
- Other (please explain) _____

16. How would you describe your general level of computer experience?

- None (I have never used any computer applications).
- Low (I have used only 1 or 2 computer applications).
- Moderately Low (I have learned and used between 3 and 10 different computer applications).
- Moderately High (I have learned and used more than 10 different computer applications but have no programming skills).
- High (I have used many different computer applications and have some programming skills).
- Other (please explain) _____

17. List all training systems you have used and the amount of experience in years or months that you have used each system.

Training System

Experience (specify years or months)

18. In general, the training systems you have used have been:

- Completely effective in training critical skills and job practices.
 Somewhat effective in training critical skills and job practices.
 Of little worth in training critical skills and job practices.
 Other (please explain) _____

19. In general, the training systems you have used have been:

- Easy to use.
 Somewhat easy to use.
 Somewhat difficult to use.
 Difficult to use.
 Other (please explain) _____

20. Are you (check one)? Male Female

21. How old are you (check one)?

- 18-25
 26-40
 41-55
 over 55

22. Do you wear glasses or contact lenses (check one)?

No

Yes (Please check your vision problem and correction method)

Nearsighted
 Farsighted
 Astigmatism

Glasses
 Bifocals
 Contact lenses

Are you color blind (check one)?

No

Yes

23. Do you have accurate depth perception? (Test: Extend your arm straight-out in front of you at shoulder height. Point your index finger to the ceiling and reference it to an object on the wall. Close one eye, then close the other. As you alternate eyes, does the finger move its position relative to the reference object?)

Yes

No

24. Do you have any physical conditions other than vision deficiencies that computer technology would need to accommodate or support (e.g., hard of hearing, arthritis in hands, wheelchair)?

No

Yes (Please describe) _____

Appendix E

Update on Casualty Mitigation Procedures for Loss of APU

Engineering Casualty: Loss of APU

Break down of the task

Dealing with the loss of APU: loss of port primary pump

- Step 1: The Engineer would first zoom into the aux screen to read the caution (note: the secondary pump caution wouldn't appear immediately, around a 30 second delay)
 - In the aux display the port pump primary should be switched to secondary (verify that port secondary pump came on)
 - The Engineer would then look at the main page to verify that port manifold pressure is steady (will be steady for about 30 seconds or so, then if the secondary fails, he will start to see it continue to decrease)
 - If the secondary fails, he will see the caution on the aux screen for the secondary
 - He will go to ME FEED page (if it shows steady pressure, then you're done – monitor on the main page or the ME/ feed/ transfer page)
 - If the pressure is not steady, then he will open crossover
 - Then, he will verify on the ME FEED page that port manifold pressure is steady, if still decreasing, he is going to close the cross over valve [in UKB]
 - If the port manifold pressure is still decreasing, the Engineer will go to the Main in UKB and take the following steps:
 - Go to main engine UKB page
 - He will set the engines to idle: problem is that the 3rd row aren't working, would hit them for 1 and 2)
 - Bring the engines to idle (UKB: M/E 1 and 2 would say IDLE, hit them both)
 - He would then stop them on the same page (UKB: M/E 1 and 2 hit stop)
 - Go back to UKB: Main
 - Go to UKB: APU ELEC
 - He would turn Gen 2 off
 - He would then reach up and secure APU #2
 - Go to UKB: main
 - Go to UKB: ME FEED
 - Close port tank valve:
 - UKB: Hit p. tank closed
 - Forward feed power off
 - UKB: hit fwd fd off
 - Finally, he would bring craft hull borne to investigate
 - Go to UKB main
 - Close cushion vanes
 - P. vane close
 - S. vane close (note: shows the actual function)

Appendix F

Usability concerns with general usability and virtual environment heuristics and their severity

Heuristic Evaluation

Presented below are the heuristic evaluation findings for both the general and virtual environment heuristics. For each heuristic a table is provided that summarizes usability concerns for that heuristic, the severity of the concern, and whether or not participants noted the concern as an issue without prompting during user testing.

General Usability Heuristics

Simple and Natural Presentation

Table F-1. Concerns with the simple and natural presentation heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
Using the mouse to interact with the UKB is not natural	Low	Yes
Using the mouse to interact with other switches, knobs, dials is not natural	Low	Not examined
Rotating point of view up with the "S" key and down with the "W" key is counter intuitive	Med	Yes
Unnatural to zoom via repeatedly depressing keys	Med	Yes
Changing point of view via repeatedly depressing keys is unnatural	High	Yes
Unnatural flow of information gathering and integration resulting from having to zoom in on the main or auxiliary display, which excludes supplemental information provided on the other screen	High	Yes
Users did not realize that the upper panels for each crewmember position were represented	Low	Yes
Users suggested horizon presentation wasn't correct, too much water, not enough sky	Low	Yes
There was no collision detection for the craft when flying overland	Low	Not examined
Alarms on engineer's auxiliary page flash in the actual craft when they have not been acknowledged, but they do not in SLEP VELCAC	Med	Yes
Inactive keys are causing confusion because they are in the incorrect non-default condition	High	Yes

Speak the User's Language

Table F-2. Concerns with the speak the user's language heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
User's language is not utilized to its fullest extent possible in the "cheat sheet"	Low	Yes

Minimize Memory Load

Table F-3. Concerns with the minimize memory load heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
Memory taxed with having to learn and remember keyboard commands	Med	Yes
Memory load is taxed by necessity to zoom in on the main or auxiliary display to read its information, which hinders ability to see the other display	High	Yes
Labeling of displays is hard to read thus requiring the user to recall from memory functionality accessed via the labeled controls	High	Yes

Consistency

Table F-4. Concerns with the consistency heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
Inconsistent function for the "1" key; first press shows Navigator's main display, subsequent press shows last point of view	High	Yes
Inconsistent functioning of the "ack" key to acknowledge alerts and alarms	High	Yes

Feedback

Table F-5. Concerns with the feedback heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
Visuals do not give any sense of craft speed	Low	Yes
No collision detection over land	Low	Yes
System locked up without telling the user why it locked up	Med	Yes
No indication of bow thruster status (stow v. operate) or direction (forward v. reverse) without viewing the synthetic HUD, which does not exist in the craft	High	Yes

Clear Exits

Table F-6. Concerns with the clear exits heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
No pause capability	Med	Yes
No ability to go back to a particular part of a scenario (can only restart)	Med	Yes
No ability to "undo" to avoid catastrophic errors	High	Yes

Shortcuts

Table F-7. Concerns with the shortcuts heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
No ability to choose where along a route or task completion to start a scenario	Med	Not examined

Errors, Error Handling, Error Prevention

Table F-8. Concerns with the error handling heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
When system locks up there is no indication of why or when via error messages	Med	Not examined
No ability to undo errors, thereby avoiding more critical errors	High	Yes
Repeated system lockups required rebooting of the system	High	Yes
When transitioning from surfzone to land the Craftmaster/Operator's heading indicator malfunctioned	High	Not examined
When flying over land the engineer's controls became inactive	High	Yes
Zoom in on engineer's main display (i.e. the 4 button) was not completely functional, it needed to be depressed numerous times (in some examples 15 times) before performing its function	High	Yes

Help

Table F-9. Concerns with the help heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
No on-line help available	High	Yes
Current paper based help does not provide timely access mid-scenario	High	Yes

Virtual Environment Specific Heuristics

Of the virtual environment specific heuristics discussed above in Table 3, only the interaction, navigation, and visual heuristics were found to have violations and thus the remaining heuristics are not listed below.

Interaction

Table F-10. Concerns with the interaction heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
Interaction with SLEP menu screens limited to UKB	Low	Yes
Engineering station does not allow interaction with buttons on overhead console	Low	Not examined

Navigation

Table F-11. Concerns with the navigation heuristic and their severity

Usability Concerns	Severity	Validated by User Testing?
External cues (waves, land, etc.) do not afford estimation of craft speed	Low	Not examined
Lack of collision detection allows user to zoom point of view outside of cockpit	Low	Not examined
Zooming should be scaled to human movements or driven by tracking head movements instead of "jumping" to an expanded view of a particular screen	Med	Yes
Movement within the VE is cumbersome due to the need for repetitive key strokes to change point of view	High	Yes

Visual

Table F-12. Concerns with the visual heuristic

Usability Concerns	Severity	Validated by User Testing?
Text on main and auxiliary displays is illegible when zoomed out and occasionally illegible when zoomed in	High	Yes
When transitioning from surfzone to land a greenish brown bar fills a majority of the screen	High	Not examined